

MARATHON OIL COMPANY

P.O. Box 2690
Cody, WY 82414-2690

ATT. Roger Thompson

**AB2588 TOXIC EMISSIONS TESTING
SOUTH COLES LEVY
SUPERIOR ENGINE C, INGERSOLL RAND ENGINE #1
AND GLYCOL REBOILER UNIT
July 7-9, 1992**

Prepared By:

BTC ENVIRONMENTAL, INC.
1536 Eastman Avenue
Ventura, CA 93003

Job Number
13045

Laboratory Report Number
292-116

Test Team Leader
Mark R. Patrick

Results Verified By
Tom Porter

BTC

**ENVIRONMENTAL
INCORPORATED**

TABLE OF CONTENTS

	Page
Summary of Results	1
A. Ingersol Rand Engine #1	2
B. Superior Engine #C	5
C. Glycol Reboiler Unit	8
I. Introduction and Sampling Procedures	10
A. Introduction	11
B. Sampling & Analytical Procedures	12
II. Calculations	14
A. Ingersol Rand Engine #1	15
1. PAH's	16
2. BTXE & Propylene	22
3. Formaldehyde	23
4. Acetaldehyde	24
5. Acrolein	25
B. Superior Engine #C	26
1. PAH's	27
2. BTXE & Propylene	33
3. Formaldehyde	34
4. Acetaldehyde	35
5. Acrolein	36
C. Glycol Reboiler Unit	37
1. BTXE	38
2. Non Methane Hydrocarbons	39
3. Hydrogen Sulfide	40
4. Glycol Ethers	43
III. Moisture & Flowrate Determinations	46
A. Ingersol Rand Engine #1	47
B. Superior Engine #C	51
C. Glycol Reboiler Unit	55
V. Laboratory Analysis	59
A. Impinger Weights	60
B. Formaldehyde, Acetaldehyde & Acrolein (AtmAA #91922)	61
C. PAH's (Calscience #92-07-112 & 92-07-113)	62
D. Glycol Ethers (Performance Analytical #3359)	68
E. BTXE & Propylene - Engines (BTC #921763)	70
F. BTXE & Propylene - Engines Chromatograms	79
G. Non Methane Hydrocarbons & BTXE (BTC #921730)	106
H. Non Methane Hydrocarbons & BTXE Chromatograms	113
VI. Methodology	140
A. Equipment List	141
B. Sample Train Diagrams	144
C. Extractive Gas Sampling System	149

TABLE OF CONTENTS (Cont)

VII. Raw Data	151
A. Ingersol Rand Engine #1	152
1. Flowrates	153
2. PAH's	156
3. Strip Charts	159
4. Engine Data Sheets	165
B. Superior Engine #C	166
1. Flowrates	167
2. PAH's	170
3. Strip Charts	173
4. Engine Data Sheets	180
C. Glycol Reboiler Unit	181
1. Flowrates	182
VIII. Quality Assurance	183
A. Dry Gas Meter Calibration	184
B. Pitot Tube Calibrations	185
C. Pyrometer Calibration	187
D. Nozzles	188
E. Calibration Gases	193
F. Continuous Analyzer Linearity Graphs	195
G. Sample Pump Calibrations	197
H. Chain of Custodies	200

SUMMARY OF RESULTS
INGERSOLL-RAND ENGINE #1

	RUN 1	RUN 2	RUN 3	AVERAGE
BENZENE				
ppmv	0.12	0.37	0.13	0.21
lb/hr	0.0009	0.0028	0.0010	0.0015
TOLUENE				
ppmv	0.15	0.11	0.05	0.10
lb/hr	0.0013	0.0010	0.0004	0.0009
ETHYLBENZENE				
ppmv	0.06	0.03	0.02	0.04
lb/hr	0.0006	0.0003	0.0002	0.0004
XYLENE				
ppmv	0.29	0.27	0.15	0.29
lb/hr	0.0045	0.0017	0.0015	0.0029
PROPYLENE				
ppmv	< 0.10	< 0.10	< 0.10	< 0.10
lb/hr	< 0.0004	< 0.0004	< 0.0004	< 0.0004
FORMALDEHYDE				
ppmv	-	-	-	8.7
lb/hr	-	-	-	0.025
ACETALDEHYDE				
ppmv	-	-	-	0.03
lb/hr	-	-	-	0.00013
ACROLEIN				
ppmv	-	-	-	0.006
lb/hr	-	-	-	0.00003

POLYCYCLIC AROMATIC HYDROCARBONS (PAH) SUMMARY

CASE #22

Client : Marathon Oil
 Site : Taft Gas Plant
 Unit : Engine #1

T std: 50 °F

Date : 7/9/92
 Job #: 13045
 Lab #: 292-116

RESULTS in lb/hr

Compound Name	RUN #			AVERAGE
	1	2	3	
Naphthalene	0.000198	0.000123	0.000168	0.000165
Acenaphthylene	0.000022	0.000012	0.000017	0.000302
Acenaphthene	< 0.000003	< 0.000002	< 0.000003	< 0.000002
Fluorene	0.000014	0.000009	0.000008	0.000010
Phenanthrene	0.000033	0.000024	0.000034	0.000031
Anthracene	0.000004	0.000003	0.000005	0.000004
Fluoranthene	0.000009	0.000006	0.000016	0.000010
Pyrene	0.000008	0.000005	0.000017	0.000010
Benzo (a) anthracene	< 0.000003	< 0.000002	< 0.000003	< 0.000003
Chrysene	< 0.000003	< 0.000002	< 0.000003	< 0.000002
Benzo(b)fluoranthene	< 0.000015	< 0.000011	< 0.000014	< 0.000011
Benzo(k)fluoranthene	< 0.000015	< 0.000011	< 0.000014	< 0.000013
Benzo(a)pyrene	< 0.000015	< 0.000011	< 0.000014	< 0.000013
Indeno(1,2,3-cd)pyrene	< 0.000015	< 0.000011	< 0.000014	< 0.000013
Dibenzo(a,h)anthracene	< 0.000015	< 0.000011	< 0.000014	< 0.000009
Benzo(g,h,i)perylene	< 0.000015	< 0.000011	< 0.000014	< 0.000013

Σ .000611

BTC Environmental, Inc. - 1992

uses full
 defect in
 as a value

**SUMMARY OF RESULTS
SUPERIOR ENGINE C**

	RUN 1	RUN 2	RUN 3	AVERAGE
BENZENE				
ppmv	0.43	0.64	0.46	0.51
lb/hr	0.015	0.023	0.016	0.018
TOLUENE				
ppmv	0.13	0.12	0.26	0.17
lb/hr	0.005	0.005	0.011	0.007
ETHYLBENZENE				
ppmv	0.05	0.06	0.09	0.07
lb/hr	0.002	0.003	0.004	0.003
XYLENE				
ppmv	0.40	0.35	0.63	0.46
lb/hr	0.019	0.017	0.030	0.022
PROPYLENE				
ppmv	3.4	3.7	3.7	3.6
lb/hr	0.065	0.070	0.070	0.068
FORMALDEHYDE				
ppmv	-	-	-	90
lb/hr	-	-	-	1.22
ACETALDEHYDE				
ppmv	-	-	-	1.4
lb/hr	-	-	-	0.028
ACROLEIN				
ppmv	-	-	-	0.19
lb/hr	-	-	-	0.005

POLYCYCLIC AROMATIC HYDROCARBONS (PAH) SUMMARY

CASE #29

Client : Marathon Oil
 Site : Taft Gas Plant
 Unit : Engine C

Test: 50 °F

Date : 7/8/92
 ID #: 13045
 Lab #: 292-116

RESULTS in lb/hr

Compound Name	RUN #			AVERAGE
	2	3		
Naphthalene	0.002332	0.002433	0.002733	0.002516
Acenaphthylene	0.000156	0.000148	0.000044	0.000302
Acenaphthene	< 0.000011	< 0.000014	< 0.000011	< 0.000010
Fluorene	0.000050	0.000042	0.000041	0.000044
Phenanthrene	0.000642	0.000676	0.000694	0.000671
Anthracene	0.000026	0.000063	0.000019	0.000036
Fluoranthene	0.000301	0.000192	0.000381	0.000291
Pyrene	0.000300	0.000150	0.000386	0.000278
Benzo (a) anthracene	< 0.000011	< 0.000014	< 0.000011	< 0.000012
Chrysene	0.000026	< 0.000014	0.000026	< 0.000020
Benzo(b)fluoranthene	< 0.000054	< 0.000071	< 0.000056	< 0.000051
Benzo(k)fluoranthene	< 0.000054	< 0.000071	< 0.000056	< 0.000060
Benzo(a)pyrene	< 0.000054	< 0.000071	< 0.000056	< 0.000060
Indeno(1,2,3-cd)pyrene	< 0.000054	< 0.000071	< 0.000056	< 0.000060
Dibenzo(a,h)anthracene	< 0.000054	< 0.000071	< 0.000056	< 0.000039
Benzo(g,h,i)perylene	< 0.000054	< 0.000071	< 0.000056	< 0.000060

Σ 0.000451

BTC Environmental, Inc. - 1992

including all detected PAHs

**SUMMARY OF RESULTS
GLYCOL REBOILER UNIT**

	RUN 1	RUN 2	RUN 3	AVERAGE
BENZENE				
ppmv	630	830	1,100	853
lb/hr	0.023	0.031	0.041	0.032
TOLUENE				
ppmv	1,100	1,300	1,200	1,200
lb/hr	0.048	0.057	0.052	0.052
ETHYLBENZENE				
ppmv	330	450	290	357
lb/hr	0.017	0.023	0.015	0.018
XYLENE				
ppmv	2,000	2,800	1,800	2,200
lb/hr	0.100	0.141	0.090	0.111
NON-METHANE HYDROCARBONS				
ppmv	23,100	29,300	37,300	29,900
lb/hr	0.38	0.50	0.65	0.51
HYDROGEN SULFIDE				
ppmv	55,200	62,800	92,000	70,000
grains/100 dscf	3,470	3,940	5,780	4,400
GLYCOL ETHERS, lb/hr				
2-Methoxyethanol	< 0.000002	< 0.000002	< 0.000002	< 0.000002
2-Ethoxyethanol	< 0.000002	< 0.000002	< 0.000002	< 0.000002
2-Butoxyethanol	< 0.000002	< 0.000002	< 0.000002	< 0.000002

* see next document
and Form PRO

RLT
3

Wang
see
Form PRO

INTRODUCTION

On July 7-9, 1992, BTC personnel performed AB2588 Toxic Emission Testing at the South Coles Levee Gas Plant located in Kern County, California. Testing was performed on the Ingersoll Rand Engine #1, Superior Engine #C and the Glycol Reboiler Unit. The facility obtains field natural gas and uses the compressor engines to compress the gas prior to the distribution to the gas plant for distribution as sales gas to Southern California Gas Company and for further fractionating into other light weight petroleum products.

Superior Engine C: Superior Model 12SGTB, S/N 317309. The engine is a turbocharged 2000 HP natural gas fired lean burn IC engine (PTO #2024035). The engine is identified as Engine C.

Ingersoll Rand Engine #1: Ingersoll-Rand Model PCG-8, S/N 8GP-2123. The engine is a 360 HP natural gas fired rich burn IC engine (PTO #2024026). The engine is equipped with a catalytic converter attached to the exhaust duct and operates a 250KW/2400V generator. A flue gas oxygen analyzer is utilized in the exhaust to monitor oxygen content.

Glycol Reboiler Unit: The steam heated glycol reboiler removes water from field gas by allowing the field gas to pass through the glycol solution. The glycol is heated by steam to remove the entrained water and then returned to the stripper reservoir. The dewatered natural gas is then piped to the gas plant for further processing.

SAMPLING AND ANALYTICAL PROCEDURES

PAH's: CARB Method 429 was used for the Polycyclic Aromatic Hydrocarbons sampling. The sample train consists of a glass nozzle, heated glass or teflon probe, heated glass fiber filter, water cooled condenser, water cooled XAD resin cartridge and cooled impingers. The sampling on the Superior engine was conducted isokinetically for 120 minutes with a total of 12 sample points from the horizontal port. The Ingersoll-Rand engine utilized a single point and a single port. All samples were retrieved in the field. A travel blank was prepared and taken on site and returned to the laboratory and treated as though it were a sample and the XAD resin was spiked as outlined in the method. The samples were sent to Calscience Environmental for analysis by GC/MS. Results are reported in μg per sample and lb/hr. See the attached sample train diagram.

FORMALDEHYDE, ACETALDEHYDE & ACROLEIN: CARB Method 430 was used. The sample train consists of a teflon probe connected to two (2) midjet impingers containing DNPH absorption solution and the third impinger contains silica gel. The sampling was conducted in triplicate for 60 minutes at a constant rate of approximately 0.5 liter per minute. New Teflon probes were used for each device. Triplicate travel blanks were prepared and taken on site and returned to the laboratory and treated as though they were samples. The samples were retrieved in the field, stored on ice and returned to the laboratory. A chain of custody was prepared and the samples along with the travel blank submitted to AtmAA, Inc. for analysis by HPLC. Results are reported in μg per sample and lb/hr.

NOTE: Due to excessive moisture in the Glycol Reboiler unit it was decided on site between BTC and SJUAPCD that testing would not be conducted for formaldehyde.

BENZENE, TOLUENE, ETHYLBENZENE, XYLENE & PROPYLENE: CARB Method 410A was used. The sampling system consisted of a stainless steel or Teflon probe, Teflon connecting line, a 5-10 liter Tedlar bag and a leak free vacuum chamber. The Tedlar bag was placed into a vacuum chamber. The Teflon connecting line was attached directly to the Tedlar bag. Sample was allowed to enter the Tedlar bag at a constant rate by applying a vacuum to the chamber and the Tedlar bag was allowed to fill over a 40 minute period of time. After the bag was filled, the bag was removed from the chamber, labeled and placed into a black plastic bag. The samples along with a travel blank were returned to the laboratory for analysis. A chain of custody was prepared and submitted to BTCE for analysis. The BTEX samples were analyzed by gas chromatography utilizing a Photoionization detection (PID) system. The Propylene was analyzed using gas chromatography utilizing a Flame Ionization detection (FID) system. The results are reported in ppmv and lb/hr.

GLYCOL ETHERS: NIOSH Method 1403 was used to determine Glycol Ethers. The sample train consists of a Teflon sample line, an iced water dropout, a charcoal absorption tube and a calibrated sample pump. The exhaust gases were sampled in triplicate at a constant rate of approximately 0.5 liters per minute for a period of 120 minutes. The condensate was recovered and placed into a VOA bottle and kept on ice. The charcoal tubes were capped and stored on ice. The charcoal tubes were submitted to Performance Analytical and analyzed for 2-Methoxyethanol, 2-Ethoxyethanol & 2-Butoxyethanol by gas chromatography utilizing a Flame Ionization detection (FID) system. Results are reported in lb/hr. There was less than 0.5 ml of condensate in each of the dropouts and therefore the dropouts were not analyzed.

SAMPLING AND ANALYTICAL PROCEDURES (Cont)

HYDROGEN SULFIDE: CARB Method 11 was used to determine Hydrogen Sulfide in the exhaust of the Glycol Reboiler. The sample train consists of a Teflon sample line connected to five (5) midget impingers and a sample pump connected to a dry gas meter. The first impinger contains 3% H₂O₂, the second impinger is dry, the third and fourth impingers contain Cadmium Sulfate solution and the fifth impinger contains silica gel. The sampling was conducted at a constant rate of approximately 1 liter per minute for 30 minutes. After sampling, the sample train was purged with clean air for 10 minutes. The Cadmium Sulfate solution was recovered and analysis was performed in the field by Iodine/Thiosulfate titration.


OXYGEN AND CARBON DIOXIDE: CARB Method 100 was used. The oxygen was determined by the use of a Teledyne 320AX electrochemical analyzer. The carbon dioxide was determined by the use of an ACS (Fuji) 3300 NDIR analyzer. The analyzers were calibrated with $\pm 1\%$ NBS traceable calibration gas before and after each run. The Glycol Reboiler exhaust gas was assumed to be ambient air of 20.9% O₂ and 0.05% CO₂.

EXHAUST VELOCITY, MOISTURE & FLOWRATE: CARB Method 1, 2 & 4 were used for the velocity & flowrate determination for the Superior engine. A total of 24 traverse points were utilized (12 at each port). The Ingersoll-Rand engine was determined using EPA Method 2C. A total of 12 traverse points were taken (6 at each port). The Glycol Reboiler was measured using EPA Method 2C with a total of eight (8) traverse points (4 points at each port). An "S" type pitot was used due to the high moisture content in the exhaust gas. Three (3) traverses were conducted and a single moisture sample were taken at each device.

All results were calculated according the IVUAPCD standard conditions of 60°F and 29.92 in of Hg. If you have any questions regarding the testing procedures or the calculations, please contact the undersigned at (805) 644-1095.

Respectfully submitted,
BTC ENVIRONMENTAL, INC.


Mark Patrick
Test Supervisor

Reviewed By: 
Tom Porter
Vice President - Air Test Division

RECEIVED

SEP 03 '92

BTC ENVIRONMENTAL
INCORPORATED

Environmental
and Safety

August 31, 1992

Marathon Oil Company
PO Box 2690
Cody, WY 82414-2690

Attention: Roger Thompson
Re: AB2588 Toxic Emissions Testing at South Coles Levy

Dear Mr. Thompson:

I have included revised calculations and summary of the Glycol Reboiler H₂S emissions. The original spreadsheets contained errors pertaining to the calculation of stack gas volume which was drawn for the H₂S testing. The corrected spreadsheets use a higher volume which greatly reduces the concentration of H₂S.

If you have any questions, please feel free to contact Tom Porter or myself.

Best Regards,

Mark R. Patrick

Mark Patrick
Testing Supervisor

**SUMMARY OF RESULTS
GLYCOL REBOILER UNIT**

	RUN 1	RUN 2	RUN 3	AVERAGE
BENZENE				
ppmv	630	830	1,100	853
lb/hr	0.023	0.031	0.041	0.032
TOLUENE				
ppmv	1,100	1,300	1,200	1,200
lb/hr	0.048	0.057	0.052	0.052
ETHYLBENZENE				
ppmv	330	450	290	357
lb/hr	0.017	0.023	0.015	0.018
XYLENE				
ppmv	2,000	2,800	1,800	2,200
lb/hr	0.100	0.141	0.090	0.111
NON-METHANE HYDROCARBONS				
ppmv	23,100	29,300	37,300	29,900
lb/hr	0.38	0.50	0.65	0.51
HYDROGEN SULFIDE				
ppmv	38	44	64	49
grains/100 dscf	2.4	2.7	4.0	3.0
lb/hr	0.10	0.12	0.17	0.13
GLYCOL ETHERS, lb/hr		*		
2-Methoxyethanol	< 0.000002	< 0.000002	< 0.000002	< 0.000002
2-Ethoxyethanol	< 0.000002	< 0.000002	< 0.000002	< 0.000002
2-Butoxyethanol	< 0.000002	< 0.000002	< 0.000002	< 0.000002

still wrong!
see Form PRO

RLT
7

Wrong!
use 1 ppm or
 $\frac{.13}{49} = .00265$

HYDROGEN SULFIDE (H₂S) ANALYSIS
ASTM D 2385

Client : Marathon Oil
 Site : Glycol Reboiler
 Sample ID : H₂S - Run 3

Date : 7/7/92
 Job# : 13045
 Lab# : 292-116

Stack Exhaust Flowrate, Qstd: 3
 Dry Gas Meter ID Number : B
 Meter Factor, (Mf) : 1.0000
 Standard Temperature, (Tstd) : 60 °F

CdSO₄ Solution : 40 g/l () 10 g/l (*)

Volume 30 ml

	Start	Stop		Averages
Sampling Time:	<u>13:42</u>	<u>14:19</u>	min.	
Barometric press, (Pb):	<u>29.80</u>	<u>29.80</u>	in. Hg	<u>29.80</u> in. Hg
DGM Temperature, (Tm):	<u>80</u>	<u>80</u>	F	<u>80.0</u> °F
Sample Volume, (Vs):	<u>0.000</u>	<u>0.243</u>	cf	

Sample Gas Volume, (Vs) = Stop Vol - Start Vol
 = 0.243008 dcf

Temp. Corr. Factor, (Tcf) = (Tm,avg+460)/(Tstd+460)
 = 1.038

Blank
 Iodine, (Ib) : 3.0 ml
 Thiosulfate, (Tb) : 2.37 ml
 Thiosulfate, (Nt) : 0.0199 N

I₂ Normality, (Ni) = (Nt * Tb) / Ib
 = 0.0157 N

Titration
 Iodine, (Vi) : 3.0 ml
 Thiosulfate, (Vt) : 0.58 ml

H₂S CONTENT = ((Vi*Ni)-(Vt*Nt)) * 787 * Tcf) / (Mf * Vs * Pb avg)
 = 4.0 grain / 100 dscf
 = [grain/100 dscf] * 54160 / (34* 100)
 = 6.4 ppmv
 = [grain/100 dscf] * 100/7000*Qstd
 = 0.17 lb / hr

HYDROGEN SULFIDE (H₂S) ANALYSIS
CARB Method 11

Client : Marathon Oil
 Site : Glycol Reboiler
 Sample ID : H₂S - Run 1

Date : 7/7/92
 Job# : 13045
 Lab# : 292-116

Stack Exhaust Flowrate, Qstd: 3
 Dry Gas Meter ID Number : B
 Meter Factor, (Mf) : 1.0000
 Standard Temperature, (Tstd) : 60 °F

CdSO₄ Solution : 40 g/l () 10 g/l (*) Volume 30 ml

	Start	Stop		Averages
Sampling Time:	<u>10:33</u>	<u>11:03</u>	min.	
Barometric press, (Pb):	<u>29.82</u>	<u>29.82</u>	in. Hg	<u>29.82</u> in. Hg
DGM Temperature, (Tm):	<u>82</u>	<u>82</u>	F	<u>82.0</u> °F
Sample Volume, (Vs):	<u>0.000</u>	<u>0.197</u>	cf	

Sample Gas Volume, (Vs) = Stop Vol - Start Vol
 = 0.197000 dcf

Temp. Corr. Factor, (Tcf) = (Tm,avg+460)/(Tstd+460)
 = 1.042

Blank
 Iodine, (Ib) : 3.0 ml
 Thiosulfate, (Tb) : 2.37 ml
 Thiosulfate, (Nt) : 0.0199 N

I₂ Normality, (Ni) = (Nt * Tb) / Ib
 = 0.0157 N

Titration
 Iodine, (Vi) : 3.0 ml
 Thiosulfate, (Vt) : 1.50 ml

H₂S CONTENT = (((Vi*Ni)-(Vt*Nt)) * 787 * Tcf) / (Mf * Vs * Pb avg)
 = 2.4 grain / 100 dscf
 = [grain/100 dscf] * 54160 / (34* 100)
 = 3.8 ppmv
 = [grain/100 dscf] * 100/7000*Qstd
 = 0.10 lb / hr

HYDROGEN SULFIDE (H₂S) ANALYSIS
CARB Method 11

Client : Marathon Oil
 Site : Glycol Reboiler
 Sample ID : H2S - Run 2

Date : 7/7/92
 Job# : 13045
 Lab# : 292-116

Stack Exhaust Flowrate, Qstd: 3
 Dry Gas Meter ID Number : B
 Meter Factor, (Mf) : 1.0000
 Standard Temperature, (Tstd) : 60 °F

CdSO₄ Solution : 40 g/l () 10 g/l () Volume 30 ml

	Start	Stop		Averages
Sampling Time:	12:20	13:05	min.	
Barometric press, (Pb):	29.82	29.82	in. Hg	<u>29.82</u> in. Hg
DGM Temperature, (Tm):	82	82	F	<u>82.0</u> °F
Sample Volume, (Vs):	0.000	0.296	cf	

Sample Gas Volume, (Vs) = Stop Vol - Start Vol
 = 0.295551 dcf

Temp. Corr. Factor, (Tcf) = (Tm,avg+460)/(Tstd+460)
 = 1.042

Blank

Iodine, (Ib) :	<u>3.0</u>	ml
Thiosulfate, (Tb) :	<u>2.37</u>	ml
Thiosulfate, (Nt) :	<u>0.0199</u>	N

I₂ Normality, (Ni) = (Nt * Tb) / Ib
 = 0.0157 N

Titration

Iodine, (Vi) :	<u>3.0</u>	ml
Thiosulfate, (Vt) :	<u>0.89</u>	ml

H₂S CONTENT = (((Vi*Ni)-(Vt*Nt)) * 787 * Tcf) / (Mf * Vs * Pb avg)
 = 2.7 grain / 100 dscf
 = [grain/100 dscf] * 54160 / (34* 100)
 = 4.4 ppmv
 = [grain/100 dscf] * 100/7000*Qstd
 = 0.12 lb / hr